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Discovery of Iron Grapnel Anchors in Early Modern Ryukyu and Management of Underwater Cultural Heritage in Okinawa, Japan

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The Yarabuoki underwater site contains seven iron grapnel anchors and Early Modern Okinawan ceramic jars and is dated to the 16th–19th centuries. The site lies at a depth of 12–32 m off the western coast of Ishigaki Island in Okinawa, Japan. Based on underwater archaeological and broadband multibeam surveys, as well as historical research of the artefacts and Early Modern Ryukyuan shipping, we discuss the possible anchor and vessel types in Ryukyu and Eastern Asia in Early Modern times. We also discuss the efficacy of low-cost ROV for assisting surveys in shallow-water environments and the value of educational programmes for promoting the management and conservation of underwater cultural heritage.

Key words: Yarabuoki underwater site, ceramic jars, ROV, high-resolution site map.

Academic and public interest in underwater cultural heritage (UCH) is increasing in Japan, partly because of the first designation of a permanently submerged site by the state government in 2011 at Takashima-Kōzaki. This site, in Nagasaki Prefecture in Kyushu, where 13th-century ships of the Yuan Dynasty China were discovered, was designated a National Historic Site after an extensive underwater

Figure 1. Location of the Ryukyu Islands including the Yaeyama Islands. (Map made by C. Katagiri)

investigation. Over the past two decades, the number of registered underwater archaeological sites subject to the Japanese Law for the Protection of Cultural Properties increased from only about 300 in 1998 to 512 sites in 2012 (Japanese Agency for Cultural Affairs, 2012: 32). Of these 512 listed sites, 34 are located in Okinawa Prefecture, one of the leading areas for underwater archaeological investigations. Okinawa Prefecture, or the Ryukyu Islands, consists of 199 islands in a chain that stretches some 1200 km between Kyushu Island and Taiwan (Fig. 1). Underwater archaeological surveys and research projects have been conducted in Okinawa since 1998. A total of 211 sites had been recognized by the Okinawa Prefectural Archaeological Center (the Center, hereafter) by 2014, many in a relatively good state of preservation (Katagiri, 2010; Okinawa Prefectural Museum, 2014). Research has been conducted by Kagoshima University and Nansei Islands Underwater Cultural Heritage Study Group (2010; 2011), the Center, Okinawa Prefectural Museum and Art Museum (for example Katagiri, 2007; 2009; 2010; Miyagi *et al.,* 2005), and the Asian Research Institute of Underwater Archaeology (2012).

The Yarabuoki underwater site near Ishigaki Island is one of those discovered by these recent surveys.

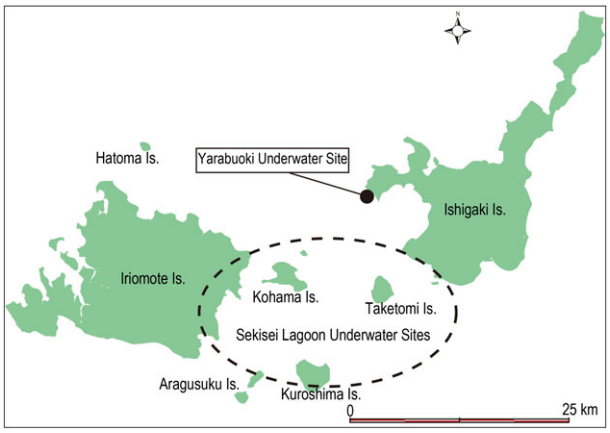

Figure 2. Location map of underwater archaeological sites in the Yaeyama Islands. (Map made by C.Katagiri)

Ishigaki is the most populated of the Yaeyama Islands, a subgroup of the Ryukyu Islands. The other major islands in the Yaeyama group are Iriomote, Taketomi, Kuroshima, Hateruma and Yonaguni. A total of 69 underwater archaeological sites are currently known off the coasts of these islands (Fig. 2). Our team

Table 1. *WGS84 position coordinate and depth of anchors and ceramics*

No.	Artefact(s)	Latitude	Longitude	Water Depth
1	No. 1 Grapnel Anchor	24°25′31.2″	124°4′22.74″	21 m
2	No. 2 Grapnel Anchor	24°25′31.14″	124°4′24.36″	13 m
3	No. 3 Grapnel Anchor	24°25′29.88″	124°4′24.24″	19 m
4	No. 4 Grapnel Anchor	24°25′25.98″	124°4′25.98″	19 m
5	No. 5 Grapnel Anchor	24°25′32.83″	124°4′16.96″	25 m
6	No. 6 Grapnel Anchor	24°25′32.94″	124°4′11.04″	29 m
7	No. 7 Grapnel Anchor	24°25′33.3″	124°4′10.98″	32 m
X	Ceramic Jars	24°25′30.18″	124°04′24.0″	20 m

is currently undertaking an interdisciplinary research project to evaluate the historical and archaeological significance and potential of the site as a cultural resource. This article presents up-to-date results of our current research and discusses the significance of the site in the context of reconstructing overseas trade routes in pre-Modern East Asia. We also report on cultural resource management practices for UCH in the Yaeyama Islands.

Discovery and investigations

The site was discovered in 2009 by a local professional diver, Mr Seiji Fujii, who has been running a diving service for more than 30 years from Ishigaki Island. He reported the approximate location of the site to the Center. In 2010, Katagiri (2010) conducted a site inspection survey as the chief investigator at the Center with the assistance of the Nansei Islands Underwater Cultural Heritage Study Group (2011). The survey confirmed the location of seven iron grapnel anchors of various sizes and a cluster of Early Modern Okinawan ceramic jars (*tsuboya-yaki*), which were originally produced in Okinawa Island from the 16th to the 19th centuries, during the Edo Period in Japan and the Early Modern Ryukyu Kingdom Period in Okinawa. They are the first grapnel anchors found in Okinawa and grapnel anchors have not previously been found in the region. Thus, these remains provide the opportunity to investigate both the past anchor types that equipped Ryukyuan and other vessels that navigated around the Ryukyu Islands and maritime trade during the Early Modern Ryukyu Kingdom Period.

Based on this preliminary survey, our aim was to locate the site with more accuracy, to find evidence for a precise date, and to attempt to characterize the site to determine, for example, if it was a harbour, anchorage, or shipwreck site.

Mapping Yarabuoki underwater site

Accurate and detailed recording is the essential first step to understand a site. Moreover, geographical and topographical data can greatly contribute to reconstructing site formation. Therefore, multiple methodologies were employed including GPS positioning (Table 1), a broadband multibeam sonar survey, the creation of a high-definition video record using a small-sized, lightweight underwater robot, and a record and analysis of each artefact.

A bathymetric map was provided by the Geospatial Information Authority of Japan (GIS) and is shown here with the location of artefacts plotted (Fig. 3). However, this map proved to be insufficiently detailed and did not accurately represent seafloor topography. To solve this problem, we conducted a multibeam echo sounding (MBES) survey around the site to visualize the bathymetric results at a lateral grid resolution of one metre.

The MBES survey was conducted in August 2011, using Sonic 2022 (R2 Sonic, LLC) and its accessory system which had been introduced to the laboratory at Okayama University in 2011, where H. Kan was affiliated. The Sonic 2022 has a variable ultrasonic frequency of 200–400 kHz with 256 ultrasonic beams and provides selectable swath coverage of 10–160°. The typical ultrasonic beam width, parallel and orthogonal to the direction of travel, is within one degree of each other when an ultrasonic frequency of 400 kHz is selected. We used a VS111 GPS compass system with A20 and A30 antennas (Hemisphere Inc.) combined with a dynamic motion sensor (DMS-10, Teledyne TSS Ltd), a sea surface sound velocity sensor (miniSVS, Valeport Ltd), and a sound velocity profiler (MicroSVP, AML Oceanographic Ltd). The sounding method is similar to that used in the Nagura Bay survey (Kan *et al.,* 2015) but the ultrasonic frequency of 400 kHz was selected for the entire area of the Yarabuoki underwater site.

The depth of the surveyed area (Fig. 3B) ranges from 0.5 to 51.0 m. The HYPACK2010 software was used for both hydrographic survey and data processing. IVS3D Fledermaus was used for three-dimensional visualization with a grid size of one metre for the entire area. The MBES bathymetric map enabled us to create a high-resolution site map on which to plot the artefacts (Fig. 3C).

Use of ROV for digital recording

An experimental part of the underwater survey at Yarabuoki, conducted by N. Sakagami and F. Takemura, used a purpose-built low-cost, portable remote operating vehicle ROV (Fig. 4) with a

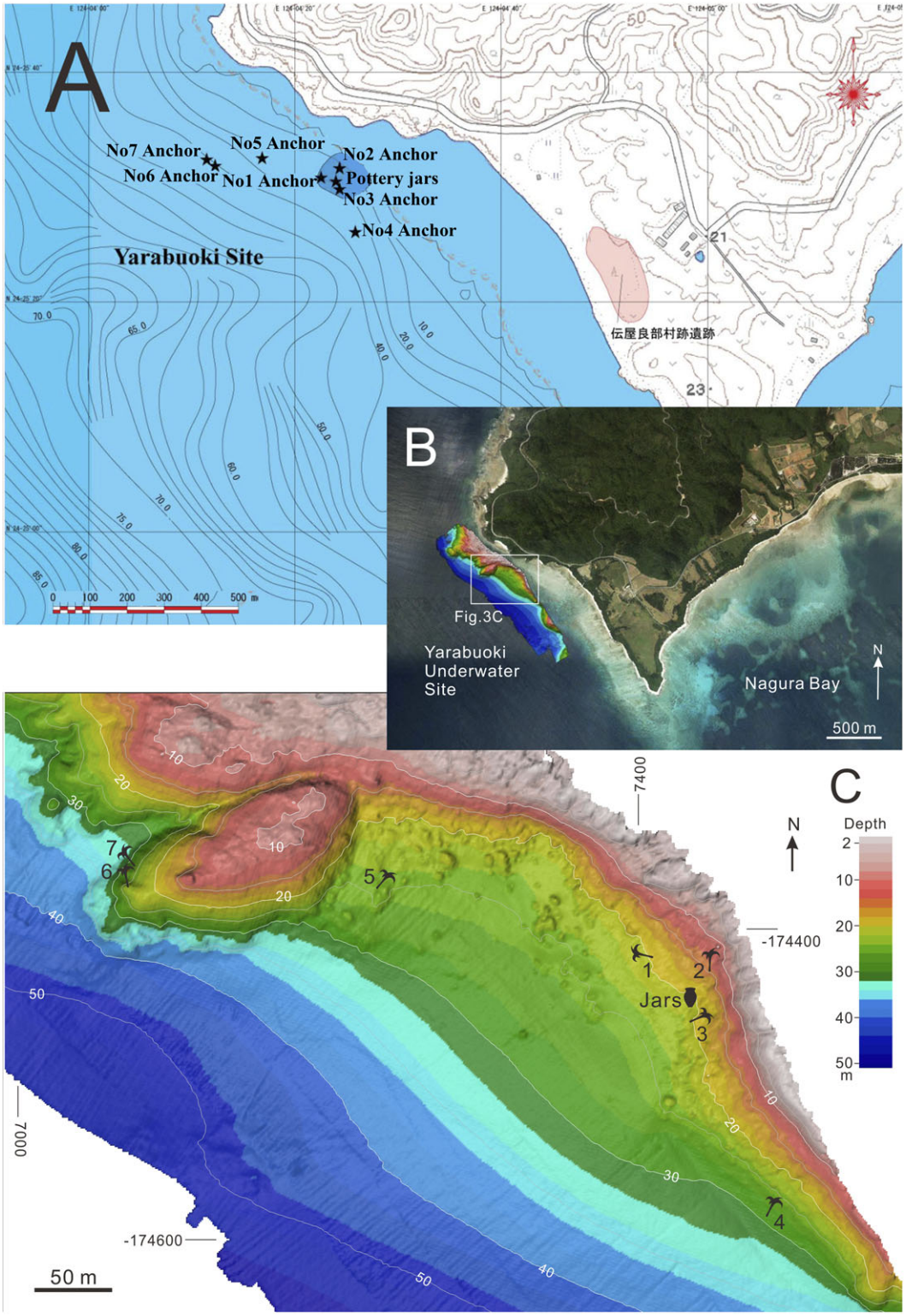

Figure 3. *a)* GIS bathymetric map with plotted respective GPS locations of anchors and jars; *b)* Coastal geomorphology with reference to our MBES survey result showing Yarabuoki Underwater Site on an aerial photograph provided by Pasco Co. Ltd; *c)* MBES bathymetric map of Yarabuoki Underwater Site showing depth contours, with the locations of anchors and jars represented in the JGD2000/Japan Plane Rectangular CS XVI coordinate system. (Made by Kan and Nagao)

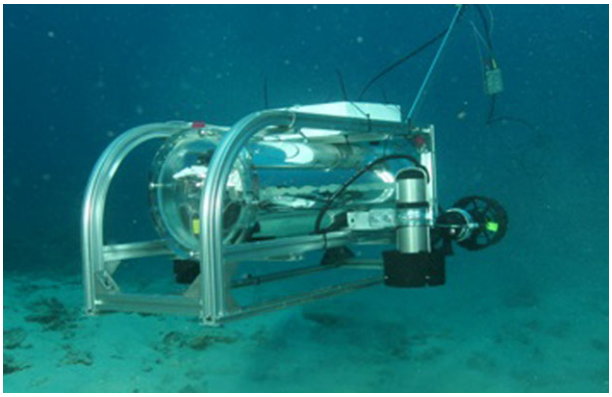

Figure 4. Underwater robot system. (Photo taken by Y. Yamamoto)

high-resolution digital video camera. Its use had the great advantage of saving time; as the survey area ranges in depth from 15 to 30 m, SCUBA divers could work for only limited periods. Anomalies could thus be captured and viewed on board via the video screen without entering the water. The ROV is 0.7 m long, 0.55 m wide and 0.3 m high, and weighs about 15 kg. It can reach a maximum depth of approximately 30 m. The robot is equipped with four thrusters to achieve surge, heave, and yaw motion: each generates a force of 2.2 kgf under water. The cylindrical waterproof housing contains equipment including a high-resolution camera, a small computer, depth sensor, magnetic compass, LED lights and batteries.

We have also developed software so that an untrained user can manoeuvre the ROV easily using a video-game controller. The aim of this system was to invite public involvement and the promotion of the site to non-divers through the experience of operating the ROV and viewing the site.

Grapnel anchors

Two separate areas of artefact concentrations have been recorded at Yarabuoki (Fig. 3). The grapnel anchors

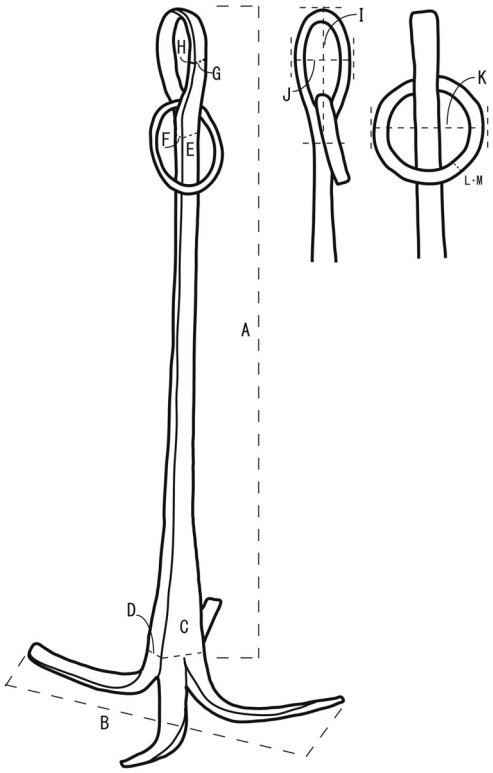

Figure 5. Measuring points of iron grapnel anchors. (Drawn by C. Katagiri)

can be divided into an eastern and a western zone, some 400 m distant from each other. Grapnel anchors Nos 1–4 are located in the eastern zone at a depth of 13–21 m, along with the ceramic jars. Anchor Nos 5–7 lie in the western zone at a depth of 25–32 m (Tables 1 and 2, Fig. 5).

The shank of anchor No. 1 measures 1.97 m. The maximum width of the shank is 0.20 m and thickness 0.15 m. All four arms survive in good condition, with two of them buried in the sandy seabed (Table 1, Fig. 6*a*). Each arm is square in section with a length of

Table 2. *Measurements of the Yarabuoki iron grapnel anchors (cm) (See* Fig. *5) ※ marks estimated values*

Element/Anchor No	No. 1	No. 2	No. 3	No. 4	No. 5	No. 6	No. 7
A (Total length)	197	180	150	120	160	165	205
B (Arm length)	※180	※120	※100	※60	103	※120	180
C (Shank max width)	20	18	12	10	10	15	20
D (Shank max thickness)	15	12	10	5	14	10	15
E (Shank min width)	10	10	7	5	9	6	8
F (Shank min thickness)	10	7	7	3	9	4	6
G (Shank loop width)	14	9	–	5	9	–	8
H (Shank loop thickness)	6	6	–	3	5	8	5
I (Shank loop Ø major axis)	8	13	–	12	22	–	10
J (Shank loop Ø minor axis)	–	6	–	9	16	–	5
K (Additional ring Ø)	–	27	–	18	30	30	34
L (Additional ring section major axis)	–	5	–	3	8	5	5
M (Additional ring section minor axis)	–	4	–	3	8	5	5

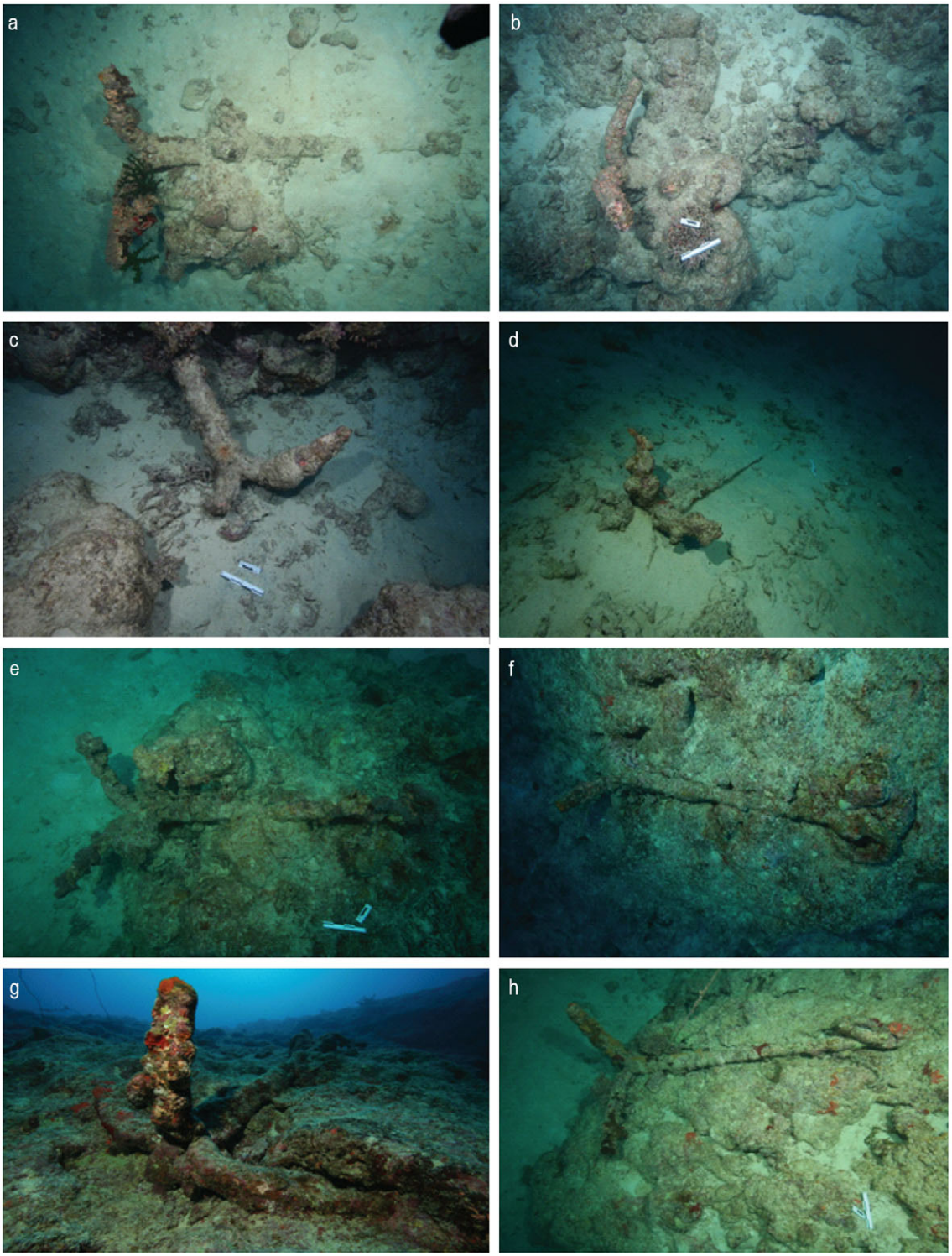

Figure 6. Iron grapnel anchors in Yarabuoki Underwater Site: *a)* No. 1 Anchor; *b)* No. 2 Anchor; *c)* No. 3 Anchor; *d)* No. 4 Anchor; *e)* No. 5 anchor; *f)* No. 6 Anchor; *g)* exposed arm of No. 6 Anchor; *h)* No. 7 Anchor (Photos taken by Y. Yamamoto)

about 1.80 m. The flukes are flattened and rectangular in shape. A loop formed at the top of the shank is 0.08 m in diameter. No additional ring is attached.

Anchor No. 2 is somewhat smaller than No. 1: its shank measures 1.80 m in length, with a maximum width of 0.18 m and thickness of 0.12 m. Of the four arms, two survive in good condition, while two of them are buried in the sandy seabed (Fig. 6b). The crown, connecting the shank and arms, is embedded in coral. The arms are estimated to be square in section with a possible arm length of 1.20 m. The shank loop is oval and measures 0.13 m by 0.06 m. An additional ring, 0.27 m in diameter, is attached to the loop.

Anchor No. 3 is much shorter than No. 1 and 2, with a shank length of only 1.50 m. Of the four arms, two of them are buried in the sandy seabed, while only the flukes of the other two are exposed. Both of the exposed flukes have been damaged and are incomplete (Fig. 6c).

The shank of anchor No. 4 is one of the shortest, being 1.20 m in length. Of the four arms, two are buried in the sandy seabed, while only the points of the other two are exposed, and these are broken and incomplete (Fig. 6d). The crown is embedded in coral, but the arm section can be seen to be square in shape. The oval shank loop is 0.12 m by 0.09 m. An additional ring of 0.18 m diameter is attached to the loop. The ring has a circular 0.03 m-diameter section.

The shank of anchor No. 5 is 1.60 m in length. All four arms survive in good condition, while one of them is buried in the hard coral seabed (Fig. 6e). The oval shank loop measures 0.22 × 0.16 m. An additional ring with a diameter of 0.30 m is attached to the loop. The ring has a circular, 0.08 m-diameter section.

The shank of anchor No. 6 is 1.65 m in length. Its maximum width is about 0.15 m. All the four arms survive in good condition. One of them is buried in the hard coral seabed (Fig. 6f, g). Both of the exposed fluke points are incomplete. The anchor crown is embedded in coral, but the cross section of the arms is confirmed as rectangular. An additional ring is attached to the loop of 0.30 m diameter. The ring has a circular, 0.05 m-diameter section.

The shank of anchor No. 7 is 2.05 m in length, with a maximum width near the crown of 0.20 m and 0.15 m thickness. Of the four arms, three are exposed in good condition and are complete (Fig. 6h), while one is buried in the coral rocky seabed. The anchor crown is embedded in corals, but the cross section of the arms can be confirmed as square. The flukes are flattened and rectangular in shape. The oval shank loop is 0.10 × 0.05 m. An additional ring is attached to the loop of 0.34 m diameter.

Distribution

The distribution of the anchors indicates that at least two or three ships lost their anchors at the site, as it is unlikely that all of these spatially dispersed anchors belong to a single ship (see Fig. 3C). There may be a relationship between the anchor sizes and their distribution. The largest two anchors (Nos 7 and 6) are located close together; as are the next two largest anchors (Nos 1 and 2). Anchor No. 4, the smallest found, in contrast, was located at some distance. The ceramic cluster is close to anchors Nos 1, 2 and 3, and thus all these finds may belong to a single ship.

Figure 7. Early modern Okinawan ceramic jars in Yarabuoki Underwater Site. (Photo taken by C. Katagiri)

Early Modern Okinawan ceramic jars

The ceramic jars are located close to grapnel anchors Nos 1, 2 and 3 on the seabed at the depth of about 20 m. In total, 12 jars have been recognized ranging in size from about 0.40 m to 1 m in height. All the jars are similar in form and material, which can be identified as the Early Modern Okinawan pottery known as *tsuboya-yaki*, originally produced on Okinawa Island (Fig. 7). The jars were recorded and left *in situ*, except for a small jar that was less embedded in the coral and easily recovered. The jar is housed in the Okinawa Prefectural Museum awaiting further study to identify the production site and precise date.

Towards evaluation of the site

Early Modern Ryukyuan ships and anchors

These are the first iron grapnel anchors discovered in Okinawa and the Ryukyu Islands. The following sections will discuss the history of shipbuilding and marine transportation of the region and possible origins of these artefacts. In terms of dating, we estimate that these artefacts belong to the Early Modern period between the 17th and the 19th centuries AD (mainly the Edo Period in Japan and the Early Modern Ryukyu Kingdom Period in Okinawa) based on our historical knowledge and archaeological chronology of Okinawan pottery and ceramics, though it is hard to determine a more precise date at this stage.

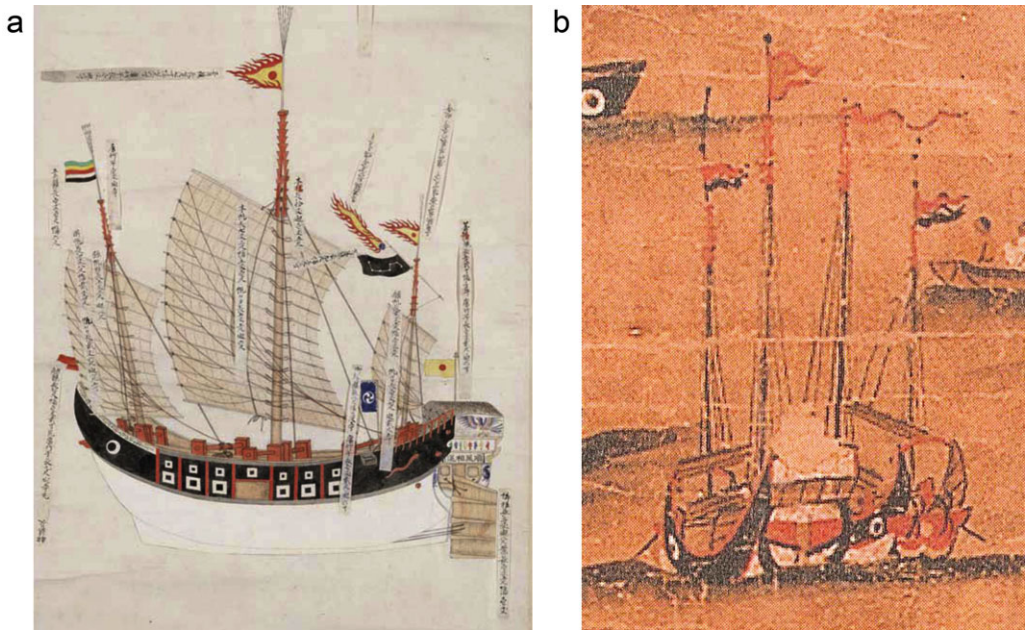

Figure 8. Depiction of *kai-sen* and *maran-sen*: *a)* picture of *kai-sen* at Tokyo National Museum Image Archives, ID C0065430A-9899 http://webarchives.tnm.jp/imgsearch/myCollection); *b)* a folding screen of the old Ryukyu trading port in Naha city (琉球交易港図 ·三幅対) of 1830–1844. (With permission of the Urasoe City Museum in Okinawa)

The Ryukyu Kingdom was an independent kingdom ruling most of the Ryukyu Islands from AD 1429 to 1874. The Kingdom was unified by Sho-Hashi, who was the last king of Chuzan Kingdom from three separated kingdoms called *san-zan* (*san* = three, *zan* = Ryukyuan dialect for 'country') including Hokuzan, Nanzan, and Chuzan in 1429. In the Sanzan Period from the early 14th century (*c*. 1322 AD) to 1429 AD, each of these kingdoms made inroads into maritime activities, and the Chuzan Kingdom settled a tributary relationship with the Ming Dynasty of China in 1372 AD (Matsuda, 2001). During the 15th and 16th centuries, the Ryukyu Kingdom thrived and was prominent in maritime trade with Southeast and East Asia for nearly 200 years (Okamoto, 2008). The Ryukyu Kingdom conquered the Yaeyama Islands at the southern end of the chain *c*. AD 1500, expanding its maritime network. In the late 16th century, however, the kingdom's commercial prosperity fell into decline, coinciding with the increased threat of *wakō*, or Japanese pirates, among other factors. The Ming gradually lost their power and interest in the region.

The Tokugawa Shogunate that had ruled Japan since AD 1601 authorized the Shimazu Clan, the feudal lord of Satsuma Domain, to send an expeditionary force to conquer the Ryukyu Kingdom in 1609. The Shimazu Clan succeeded in occupying the Ryukyu Kingdom in the same year. In 1644, when the Qing Dynasty took over the former Ming Dynasty in China, the Ryukyu Kingdom remained a tributary state. The Tokugawa Shogunate formally approved this arrangement in 1655. Here, we define the Early Modern Ryukyu Kingdom as having started with the invasion of the Shimazu Clan of Satsuma in 1609 and ended with the formal annexation by the Japanese State in 1879.

There were three major types of trading ship during the Early Modern Ryukyu Kingdom. The largest ships were *shinko-sen* (*sen* = ship) (進貢船) and Ryukyuan *kai-sen* (楷船), and were a type of junk. S*hinko-sen* were used for international trade, mainly with China (Ming and Qing Dynasty), while the Ryukyuan *kai-sen* (Fig. 8a) were often second-hand *shinko-sen,* repurposed for local trade between Satsuma and Ryukyu once the armaments had been taken off. Another ship type, *maran-sen* (馬艦船) were middle to small-sized wooden junks (Fig. 8b) made by Ryukyuan merchants for domestic trade, mostly within the Ryukyu Kingdom (for example Tomiyama, 2012).

A *shinko-sen* could also be called *To-sen,* or 'Chinese ship', as they were predominantly used for international maritime trade between Naha, the capital port of the Ryukyu Kingdom, and Fujian (Fuzhou) in China. Between AD 1383 and around 1450, *shinko-sen*-type vessels were granted to the Kingdom by the Ming when Ryukyu became a tributary state. Possibly more than 30 vessels were granted to the Ryukyu Kingdom over a period of 70 years (Okamoto, 2008). These granted Chinese-built ships seemed to be separated in two types by size: 1) large-sized vessels with a loading capacity exceeding about 600 kL/m^3 or a capacity of over 200 persons, and 2) middle-sized vessels with a loading capacity exceeding about 300 kL/m^3 or a capacity of about 100 persons, based on Ryukyuan historical

documents (for example Yamagata, 1996; Okamoto, 2008).

However, when such grants from China ceased in the mid 15th century, the Ryukyu Kingdom appears to have started building such vessels at certain Fujian dockyards until around the early 16th century. Although the details are unclear, some historic documents (for example '*Rekidai Hōan'* or 歴代宝案, which recorded the diplomatic activities of the Ryukyu Kingdom from 1424 to 1867 AD in a total of 270 volumes) mentions that the Kingdom sent timber and materials for shipbuilding from the Ryukyu Islands to Fujian and ordered the dockyards there to build *shinko-sen*-type ships (Okamoto, 2008: 227). By *c.*1570 AD, the Ryukyu Kingdom had started to build *shinko-sen* themselves within the Ryukyu Islands, mainly on Okinawa Island, and continued until 1609 AD, when the Ryukyu Kingdom was occupied by the Satsuma Clan (for example Owada, 1993; Yamada, 2007; Okamoto, 2008). Interestingly, the historical records describing these vessels newly built in Fujian and later in the Ryukyu Islands up until *c.*1510, were much larger than the previously granted Chinese vessels and their loading capacity can be estimated at over 600 kL/m^3 with maximum capacity of 366 persons or average capacity of over 200 persons. The use of larger ships by the Ryukyu Kingdom during this period also indicates the expansion of maritime trade with the Ming. After *c*. AD 1520, however, the size of Ryukyuan-made ocean-going vessels reduced their average loading capacity and seldom exceeded 300 kL/m^3, or a capacity of about 100 persons (Okamoto, 2008: 225–6), and such middle-sized vessels seemed to have continued to be built or used after the Early Modern Ryukyu Kingdom Period.

During the Early Modern Ryukyu Kingdom period, the Kingdom also had started to purchase old Ming ships, as well as constructing similar ships itself (Tomiyama, 2012: 197–209). The Ryukyuan *kai-sen* and *maran-sen* share the same basic ship structure as the *shinko-sen* and they were used up to the 18th century for local trade by private merchants between Naha and Kagoshima, the capital of Satsuma Domain in the southern part of Kyusyu Island. The construction of *maran-sen* started in the early 18th century.

The actual sizes of these Early Modern Ryukyuan ships are estimated by Tomiyama (2012) from the 19th-century drawings *Senpaku Zumen Gomai* ('Five ship plans': 船舶図面五枚) owned by Tokyo National Museum (2002). As shown in Table 3, *shinko-sen* and *kai-sen* are the largest with their hulls as long as 34.8 m, and 9.7 m in the beam, while *maran-sen* vessels are much smaller with a maximum hull length of only 14.2 m and beam of 5.4 m. Another historical record *Ryukyu han zakki go,* dated to 1873 (Minutes of Ryukyu Domain vol. 5: 琉球藩雑記五, originally edited by Ministry of Finance Japan in 1873 and re-edited by the Ryukyu Government in 1965), mentions the loading capacity of *shinko-sen* and *kai-sen* as 189 tonnes or 1260 *koku* (1 *koku* = 150 kg).

Table 3. *Dimension in metres of ships during the Early Modern Ryukyu Kingdom*

Ship part/ship type	*Shinko-sen*	*Kai-sen*	*Maran-sen*
length	34.8	34.8	14.2
breadth	9.7	9.7	5.4
depth	5.4	5.4	3.3
stern height	8.2	8.2	4.5
bow height	7.6	7.6	4.3
main mast (height)	30.3	30.3	13.6
main mast (width)	4.5	4.5	1.8
main sail (length)	22.1	22.1	11.5
main sail (width)	15.4	15.4	8.1
mizzen sail (length)	7.6	7.6	–
mizzen sail (width)	4.5	4.5	–
fore sail (length)	14.5	14.5	6.6
fore sail (width)	7.2	7.2	4.5
fore mast (height)	16.6	16.6	9.3
fore mast (width)	2.4	2.4	1.5
helm pole (height)	9	9	4.2
helm pole (width)	2.4	2.4	0.7

(Based on Tokyo National Museum, 2002 and Tomiyama, 2012: 26)

The same document also mentions there were eight vessels classified as the largest sized ship of more than 1260 *koku* (= about 300 kL/m^{3}or a capacity of about 120 persons) or with 15 *tan* (反) sized sail (1 *tan* = 991.74 m^2). Among those noted in the document, three vessels are classified as *shinko-sen* and *kai-sen* types. Two are classified as Ryukyu-made *kai-sen*-type vessels. The privately owned ships, *maran-sen,* are more diverse in size. The loading capacity for the largest type is about 51 tonnes (340 *koku*), while the smallest type is about 14.4 tonnes (40 *koku*). Another section in the same document also mentions that there was a total of 12 of these smaller-sized vessels, with 7–12 *tan* sized sails, in 1873. Many much smaller vessels, with sails not exceeding 6 *tan,* also existed at this time: 77 with 6-*tan*, 24 with 5-*tan*, and nine with 4-*tan*-sized sails (Tomiyama, 2012: 28).

No written documents that identify the anchor types that equipped a *shinko-sen* have been discovered as yet, but there are some drawings. On the folding screen showing the *shinko-sen* (進貢船の図) during 1830–1844 owned by the Okinawa Prefectural Museum and Art Museum, seven *shinko-sen* are depicted with their anchors (Figs 9a and b). These anchors are possibly much older Asian-style wooden anchors, rather than iron grapnels. The use of wooden anchors can be seen on other drawings including another folding screen depicting *shinko-sen* dated to the 19th century (owned by Okinawa Prefectural Museum) and the iconographic record of the voyage under the command of Captain Frederick William Beechey, which visited Ryukyu on May in 1827 (Beechey, 1831). The size of such wooden anchors used with *shinko-sen* has been estimated by

Figure 9. *Shinko-sen* with its anchors depicted on a folding screen of 1830–1844 (進貢船図) (With permission of Okinawa Prefectural Museum and Art Museum in Naha)

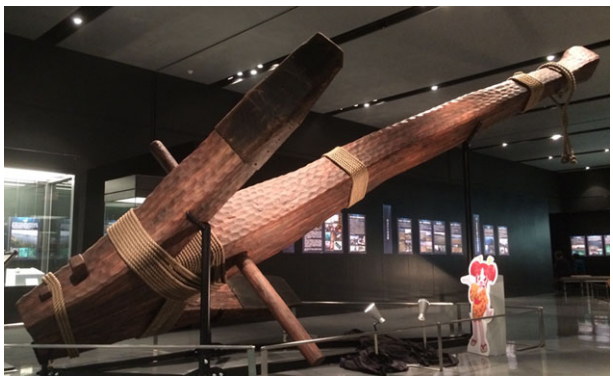

Figure 10. Reconstructed wooden anchor for a *shinko-sen*, total length 7.5 m, on display at Okinawa Prefectural Museum and Art Museum. (Photo taken by C. Katagiri)

Okinawa Prefectural Museum at 7.6 m in length and 3.62 m in maximum width between each arm (Fig. 10).

One of the Ryukyuan *kai-sen* also appears in the historical document *Ōshima zakk*i (Ōshima Records: 大島筆記) written by Tobe Yoshihiro (戸部良熙), which records that a Ryukyuan *kai-sen* departed Naha port, but failed in its course and drifted to Ōshima in Tosa Domain (present Kochi Prefecture in Shikoku Island) in 1762, was equipped with both wooden anchors and iron grapnel anchors. Since Ryukyuan *kai-sen* were often repurposed *shinko-sen* type ships, it is possible that *shinko-sen* were also equipped with both wooden anchors and iron grapnel anchors. Another well-known account, *Zhongshan chuanxin lu* (中山伝信録) written by Xu Bao Guang (徐保光), who was the deputy envoy of a Chinese mission for the investiture of King Sho Kei and arrived in Ryukyu in 1719, also reports their Chinese-type vessels called *hou-sen* (封舟) that visited Ryukyu were equipped with both wooden and iron grapnel anchors, and includes a detailed illustration (Fig. 11). Since the Early Modern Ryukyuan ships were constructed following the Chinese shipbuilding tradition, it is presumed that the Ryukyuan ships' anchors were probably identical to the Early Modern Chinese ships' anchors.

Although the historical documents and records concerning *maran-sen* and their anchors are very limited in number, the folding screen *Ryukyu kōeki zu byōbufu* depicts a *maran-sen*-type vessel with iron grapnel anchors (see Fig. 8b). Therefore, it is likely that all three types of Early Modern Ryukyuan ships were equipped with both wooden and iron grapnel anchors.

Notably, ships from both China (Fujian) and Satsuma that visited the Ryukyu Island were equipped with iron grapnel anchors. According to another drawing of the old Naha port on a 19th-century folding screen (Fig. 12, owned by Okinawa Churashima Foundation Syurijyo Park), some Satsuma ships were also equipped with iron grapnel anchors (Katagiri, 2011). Since the Ryukyu Kingdom was dominated by Satsuma after AD 1609, there are some records that the Ryukyuan people chartered Satsuma ships to sail between Naha and Satsuma or Naha and the Yaeyama Islands (Okinawa Educational Committee, 2005). As shown in Figure 12, the Satsuma ships were depicted as Early Modern Japanese-type vessels in wood, also called *kai-sen* (廻船), which is different from the Ryukyuan *kai-sen* (櫂船) described above. The

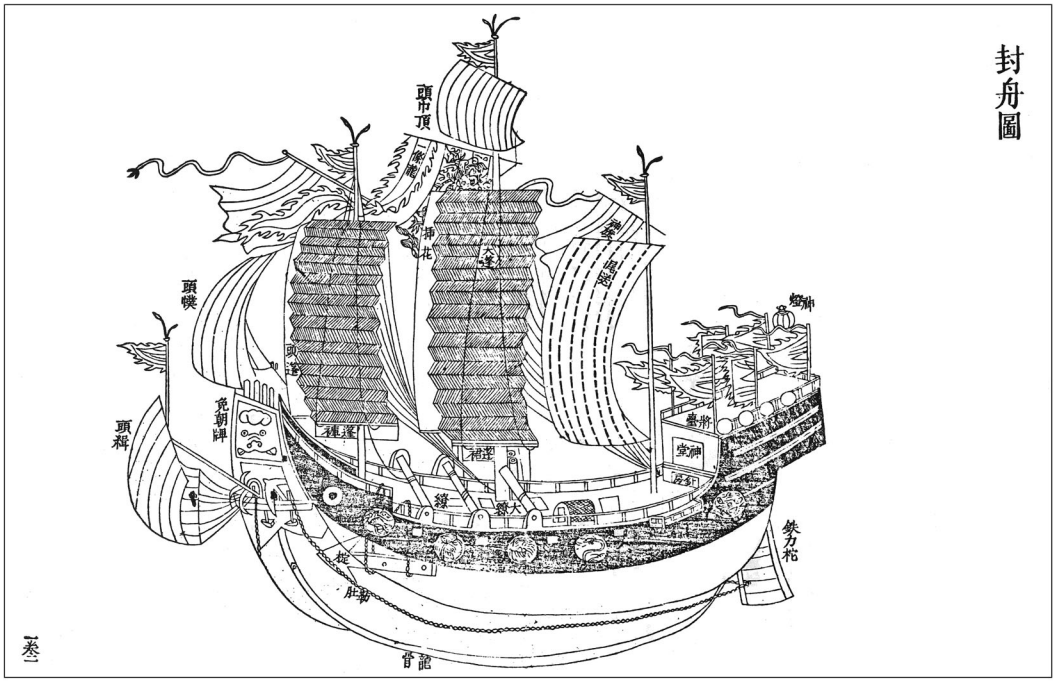

Figure 11. Early modern Ryukyuan ship with wooden and iron grapnel anchors in Zhongshan chuanxin lu (重刻中山傳信録の内「封舟図). (With permission of Okinawa Prefectural Museum and Art Museum)

Figure 12. Satsuma ships in old Naha port on the folding screen from the folding screen of Naha trading port (那覇港図屏風　第三扇) in the early 19th century. (With permission of Okinawa Churashima Foundation Syurijyo Park)

majority of *kai-sen* used in Satsuma and many other places in Japan were originally constructed as trading ships during the Early Modern times. Since the above-mentioned vessels from both Satsuma and China were equipped with iron grapnel anchors, the anchors found at Yarabuoki could be from either Japan or China.

Grapnel anchors in China and Japan

Iron grapnel anchors were originally invented in China possibly during the Ming Dynasty (Matsui, 2013).

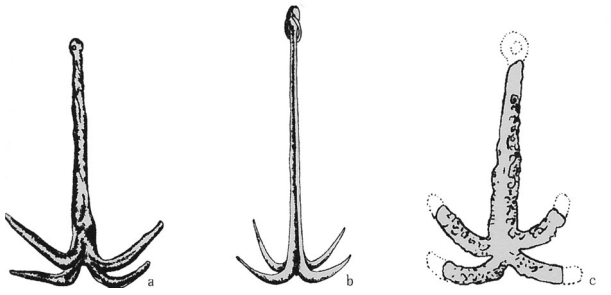

Figure 13. Excavated iron grapnel anchors in China not to scale. (Wang, 2000:149, 277–8)

Some have been excavated in China: the oldest has a total length of 1.36 m and was found in Shandong Province in 1956. The anchor has an inscription on the upper shank that indicates that it was made in 1372 (Wang, 2000; see Fig. 13b). Two other grapnel anchors excavated in China are also as large: one excavated from Shandong Province in 1984 measures 2.15 m in length and weighs 456 kg (Fig. 13a), while another one from Fujian Province, excavated in 1981, is 2.68 m in length and weighs 758.3 kg (Fig. 13c).

In Japan, the oldest historical documents depicting iron grapnel anchors are the *Shinkō Kōgo Rokuengi Emaki* ('Empress Jingū auspicious picture scroll' or 神功皇后縁起絵巻) of 1433 and the *Boshi nyūminki ki* (戊子入明記) of 1486 (re-edited by Kondo, 1912). Thus these iron anchors were possibly used in conjunction with wooden anchors and anchor stones until the early

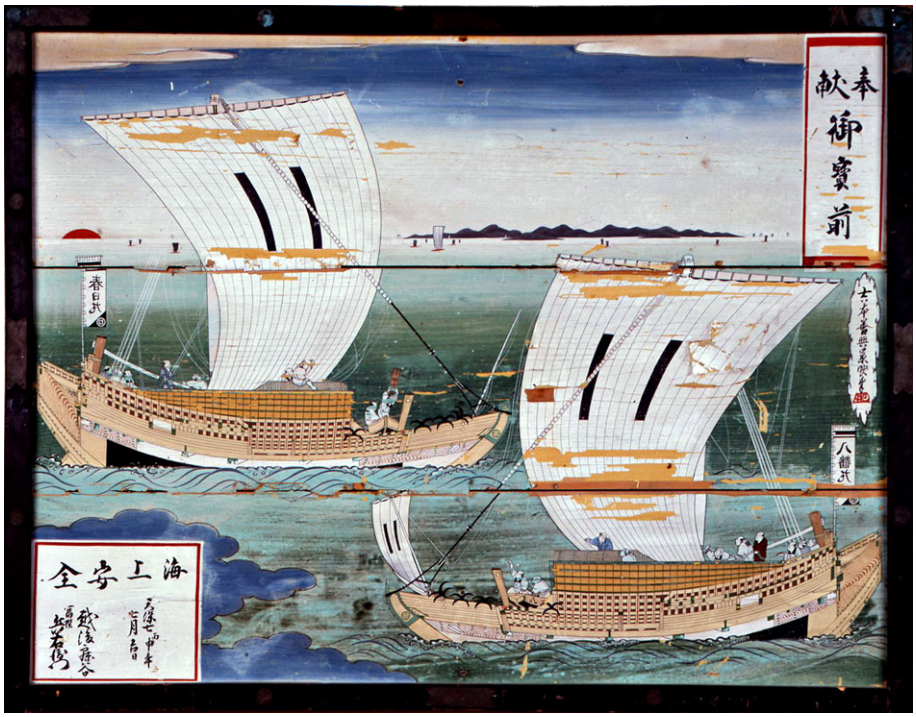

Figure 14. *Bezai-sen* and its iron grapnel anchors depicted on the votive picture dedicated to the Engaku-ji temple in 1836 (Kon, 2012: 74, fig. 12, With permission of Engaku-ji and Kon)

15th century (Ishii, 1983: 322–6). Nevertheless, by the 17th-century iron grapnel anchors had become the main anchors used for later Japanese wooden ships such as *kai-sen* or *bezai-sen* during the late Edo Period of the Tokugawa Shogunate. *Bezai-sen*-type vessels that originated in the Setouchi Sea area, in western Japan, had become the major ship type in Early Modern Japan by AD 1700 (Fig. 14).

One *hokkoku-sen*, one of the *kai-sen* (廻船) type ships of Northern Japan, drawn in 1633 on the votive picture dedicated to the Enkaku-ji Temple in present Aomori Prefecture, Northern Japan, was equipped with iron grapnel anchors (Fig. 15). Among *bezai-sen*-type ships, the common *higaki kai-sen* ships, which originated in the Osaka area, started to be used from 1619 for the export of various commercial goods from western Japan to Edo or other eastern parts of Japan (Tomiyama, 2012). In the 17th century there were approximately 1200 to 1300 vessels of this type in Japan (Kojima, 2012: 109).

The larger *bezai-sen* is called *sengoku-sen* or *sengoku-bune* (*sen* = a thousand, *goku*/*koku* = basic unit of volume used during the Edo Period, *-sen* or *bune*/*fune* = ship) with loading capacity exceeding 278 kL/m^3, a thousand *koku*. The average loading capacity for a *sengoku-sen* is around 1200 *koku*, which is almost the same size as a Ryukyuan *shinko-sen*. *Sengoku-sen* were usually equipped with seven different sized iron grapnel anchors identified as the first anchor to the seventh anchor. The largest was over 2 m in length and weighed 80 *kan* (= 300 kg), with each of the following weighing 5 *kan* (18.8 kg) less; thus, the seventh anchor weighed 50 *kan* (= about 180 kg) (Kojima, 2012: 119) (Table 4). This suggests that *sengoku-sen* (about 1200 *koku*) class vessels were equipped with anchors weighing from 180 to 300 kg. Much larger vessels (for example the 1500 *koku* class) would have been equipped with correspondingly larger and heavier anchors. For example, an iron grapnel anchor weighing about 340 kg with a total length of 2.80 m was salvaged from Kōzu Island underwater site, along with a number of Early Modern ink stones, stone lanterns and ceramics dated to AD 1800–1850. Since the Kōzu Island anchor weighs more than 300 kg, it is thought to be the first known anchor for a 1200–1500 *koku*-class vessel.

Table 4. *Relationship between anchor size and weight in the 19th-century bezai-sen*

Anchor No.	Weight (*kan*)	Weight (kg)
No.1	80	300
No.2	75	281
No.3	70	262
No.4	65	243
No.5	60	224
No.6	55	206
No.7	50	187

Based on this information, the larger-sized grapnel anchors at Yarabuoki, which measure about 2 m in

Figure 15. *Kai-sen* and iron grapnel anchors depicted on the votive picture dedicated to the Engaku-ji temple in 1633.

length, were possibly those of one or more *sengoku-sen*. Considering that the jars found at the site are *tsuboya-yaki*, Early Modern Okinawan ceramics originally produced in Naha City on Okinawa Island, the Yarabuoki grapnel anchors Nos 1, 2 and 3 could have equipped a Japanese-style *kai-sen* or Ryukyuan-style *maran-sen* vessel(s), probably from Satsuma or Naha. However, they could have also belonged to Chinese vessels making unintentional visits to Ishigaki Island when voyaging between Naha and Fujian and the other islands in the Yaeyama group. It is also known that some of the Early Modern Chinese vessels (mainly war ships from Fujian according to Dr Tsang, pers. com. 2014) were usually equipped with iron grapnel anchors.

In fact, there are two local historic documents dated to 1685 that record the mishaps of possible Chinese vessels in the coastal sea off Yarabuzaki, the promontory close to Yarabuoki underwater site. The *Shan-Sei Kafu Hedona Ke* ('Genealogy Book of the Shang Clan, the *Hedona* Family': 尚姓家譜辺土名家), recounts that a small Chinese ship departed Naha port heading to China on 7 December 1685, with the intention of returning to Naha the following July, but was wrecked and sunk 16 July 1686 off the coast of Yarabuzaki, with the death of many of the crew members. Another document *Gosei-Kafu Kudaka Ke* ('Genealogy Book of the Wu Clan, the *Kudaka* Family' or 呉姓家譜 久高家) records that a small Chinese ship departed Naha on the 11 March and arrived in China on the 23 March in 1686. It departed again on the 16 July to return to Naha, but was wrecked around Yarabuzaki on the 23 July 1686. The account states that the ship's cargo was salvaged between 29 July and the 4 August, suggesting that the ship did not sink immediately. Both ships sunk off Yarabuzaki in July, possibly during the high typhoon season in 1686.

These historical documents explicitly mention that Chinese ships sunk close to the Yarabuoki underwater site, thus the anchors could belong to Ryukyuan or Satsuma vessel(s), or Chinese vessel(s). More detailed analysis, including precise drawing of each anchor for reconstruction and comparative studies with other Early Modern iron anchors in China and Kyushu, particularly in Satsuma, may enable distinguishing features to be established.

Discussion

Maritime transport in the Ryukyu Kingdom

In order to clarify the characteristics of Yarabuoki underwater site and its artefacts, this section incorporates the results of our survey with the local historic and social context, particularly regarding the history of maritime transportation in the Ryukyu Kingdom. In the Yaeyama Islands including Ishigaki Island, there was no historically recorded trading port under the rule of the Ryukyu Kingdom (AD 1429–1879), and loading and discharging cargo was presumably done off the coast, by anchoring ships

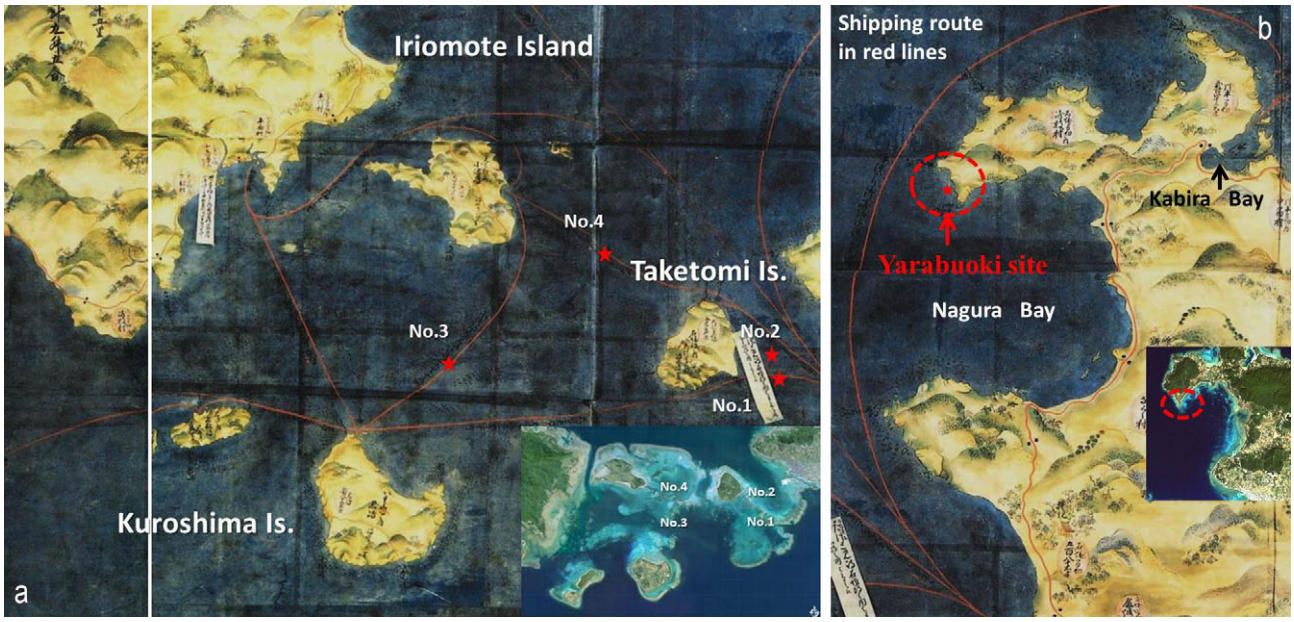

Figure 16. Two of the first major maps of the early modern times (島津領国絵図, 正保琉球国八山島絵図写) showing the shipping routes around Iriomote and Ishigaki Islands in the 17th century. (With permission of Historiographical Department of the University of Tokyo)

Figure 17. A ship nail in the area of clustered pottery jars at Yarabuoki Underwater Site. (Photo taken by C. Katagiri)s

in the bays and lightering cargo between the ship and the land (Oohama, 1999). For instance, Nagura Bay and Kabira Bay on the west coast of Ishigaki Island, as well as other anchorage points, were recorded as safe havens in the historic document and drawings known as *Sho-ho-no-Kuniezu* (正保国絵図) that were the first major maps of the Early Modern times.

The Tokugawa Shogun, seated at Edo, ordered feudal lords all over Japan to make these maps in the period AD 1644–1651. Following the order, the Satsuma Domain produced detailed shipping-route maps in 1651 covering an area from the Satsuma coasts and the Ryukyu Islands including the Yaeyama Islands. One of the maps covers Sekisei Coral Lagoon between Ishigaki and Iriomote Islands (Fig. 16a). It can be shown that most of the UCH sites around these islands are located exactly along the past shipping route (Fig. 3), particularly in the area of the shallow lagoon. This is not a coincidence, but indicates that these underwater sites are highly correlated with maritime incidents connected to these trade routes in the past.

The Yarabuoki underwater site is located along one of the major domestic shipping routes from the north coast of Yarabuzaki Promontory that forms the large Nagura Bay (Fig. 16b). The bay has long been known to hold one of the anchorage points used during the Early Modern times. In fact, local historical records relate that the bay was used as an export port in AD 1734 and AD 1772 (cf. 'Extracts from the Report by the Bearer' or 参遣状抜書, 1734; 'Genealogy Book of the Makata Family from the Second Chief of *Mashi* Clan' or 麻支氏大宗真方家譜,1772). The documents also noted the risk of being stranded on submerged shore reefs in Yarabuoki.

Based on these historic records, the grapnel anchors from Yarabuoki could be from ships that departed Naha port on Okinawa Island, the capital of Ryukyu Kingdom, or Fujian in mainland China. Although Chinese ships usually attempted to sail directly between Naha and Fujian, some failed and drifted on to Ishigaki Island as discussed. Also, after 1609, the Satsuma ships as Japanese *kai-sen* type and Ryukyuan *maran-sen*-type ships, mainly owned by Satsuma or Ryukyuan merchants, sailed between Satsuma and Ishigaki via Naha. So these three ship types could have arrived at or drifted to Yarabuoki.

Geographically, the site is located in the west coast of Ishigaki Island, where a westerly wind is rare at all times of the year (see Kan *et al.,* 2015) (Fig. 2). In addition, the coast of Ishigaki Island is almost entirely fringed by coral reefs extending from several hundred metres to one kilometre wide. It is, however, located close to the shore because the coral reef is not so developed in the area around the site as in the other areas around the island (Fig. 3B). No. 2 anchor is about 20 m from a shoal of only 2–3 m depth, and the distance to the closest beach is about 200 m. Similarly, the distance from Nos 1 and 3 anchors to the shoal is 30–50 m, and 230 m to the beach.

The MBES bathymetric map (Fig. 3C) shows the seafloor topography of this coast is formed by a steep slope extending over a distance of 10 m from the shoal to the deeper area. It appears that the coastal geomorphology around Yarabuoki underwater site provides ideal conditions for an anchorage point and a natural harbour for the following reasons: 1) steep seafloor topography beyond the shoal; 2) the embayment lies leeward of the island; and 3) a short distance to the beach. Moreover, a large offshore reef (top depth of 9 m, maximum width 90 m and 200 m long) can be seen on the MBES bathymetric map (Fig. 3C), where two anchors (Nos 6 and 7) are located on its north-western side. This offshore reef was mentioned by some historical documents as discussed above.

The distribution pattern of the anchors in Yarabuoki indicates that these anchors could belong to two or three ships, but probably not to a single vessel. The scenario of the site being the remains of a Japanese *kai-sen* equipped with all seven anchors is unlikely, not only because of the spatial distribution, but also because of big size gap between the larger anchors and smaller ones. This will be better demonstrated if the weights of the Yarabuoki anchors can be obtained in the future. Moreover, the historical records report that several ships are known to have sunk around Yarabuoki in the past.

Although we have not yet found any hull remains, and further work, including trial excavations, in particular around the area with clustered ceramic jars is programmed, the rarity of the iron grapnel anchors, linked to the analysis of the geography and form of the seabed, have revealed a site of great interest. The anchors could have arrived when trading vessels plying the route between Naha and Fujian or Naha and Satsuma drifted onto the reefs, or as a series of losses in a recorded anchorage used for domestic trade within the Ryukyuan Kingdom. It cannot yet be determined if the site represents shipwreck(s); or jettisoned artefacts including iron grapnel anchors and ceramic jars (Ono *et al.,* 2013). Nevertheless, a ship nail was found beside the ceramic jars (Fig. 17) during our survey in 2013. This indicates, together with the distribution of anchors Nos 1 to 3 around the clustered ceramic jars in area of about 60 m diameter, the potential for wrecked hull remains buried in the sandy seabed. Further research, including excavation, should enable further clarification.

Management of UCH in Okinawa

In order to protect this precious UCH, public understanding and involvement are essential, and a particular effort must be made to engage local residents who have constant access to the site. As part of our interdisciplinary project, we have promoted several public archaeology projects. Since the Ryukyu Islands, including the Yaeyama Islands, are located in a sub-tropical climatic zone with well-developed coral reefs, they are the most popular diving area in Japan. There is great potential for using UCH, including the Yarabuoki underwater site, as cultural, educational and tourist resources if the local community is engaged to appropriately manage and conserve the sites (Ono *et al.,* 2013).

The research presented in this article is the essential first step in recognizing the significance and potential of UCH sites. The second stage is the dissemination of research outcomes to the wider public, particularly the local community. For the third stage, we would point to the importance of conducting educational and cultural programmes to pass historical significance and future potential of this UCH to the local younger generations of school students. Therefore, we engaged school students by using small-sized low-cost underwater robots to investigate shallow coral reefs near the shore of Ishigaki Island. In these trials, we provided local high school and junior high school students with easy-to-make robot kits and instructions in August 2013 and 2014. When the students had finished building the kits, they took their robots to the beach to operate them using video-game controllers, smart-phones or tablets, to observe the underwater environment. Moreover, we were then able to conduct a survey using both scuba diving and underwater robots on the Yarabuoki underwater site with the help of some local high-school students who were part of the robot-making programme (Takemura *et al.*, 2013; Sakagami *et al.*, 2014).

We have also held two public meetings in Ishigaki city in February 2014 and 2015 and invited school teachers, students, and members of the local board of education to discuss the potential of the UCH around Ishigaki Island, including its use for educational and cultural programmes. Our next step is to help create a local group with core members who can actively work to conserve their UCH and oversee the resource. As stated by some Japanese scholars (for example Katagiri, 2010, Katagiri *et al., 2012*, 2014; Iwabuchi, 2012; Ono *et al.,* 2014), the concept of establishing underwater site museums that preserve and present UCH *in situ* may be an ideal way to use and manage such sites in the Yaeyama and Ryukyu Islands in the near future.

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